AMBIENT AIR QUALITY IN THE SARNIA AREA

ANNUAL REPORT 1981

Ministry of the Environment
Ontario

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IN THE
SARNIA AREA

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Technical Support Section
Southwestern Region
ONTARIO MINISTRY OF THE ENVIRONMENT

October, 1982

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SUMMARY

Ambient air quality monitoring in the Sarnia area revealed appreciable improvement in the 1981 levels of sulphur dioxide and particulates compared to levels for previous years. Levels of carbon monoxide and nitrogen dioxide continued to meet the criteria for desirable ambient air quality.

In April 1981 a new regulation was passed requiring additional controls on sulphur dioxide emissions when ambient levels of sulphur dioxide approach the 24-hour criterion for desirable ambient air quality and persistent meteorological conditions conducive to elevated levels of sulphur dioxide are forecasted. This regulation has been successful in reducing excursions above the 24-hour criterion.

Throughout Ontario elevated levels of photochemical oxidants in the form of ozone are experienced during the spring and summer. These elevated levels are a result of the long-range transport of ozone and chemicals that react to form ozone, as well as photochemical reactions involving local emissions. The elevated levels of ozone primarily occur when there are southerly winds associated with weather systems favourable for photochemical reactions and the long-range transport of pollutants. Adequate control of ozone will be dependent on the development of control strategies at local and international levels. Ozone is being addressed jointly by groups in the United States and Canada. The U.S. Environmental Protection Agency is requiring states to implement control strategies that will ensure attainment of the U.S. primary air quality standard for ozone by December 31, 1987. This standard (0.12 ppm averaged for 1 hour) is less stringent than Ontario's

criterion for desirable ambient air quality (0.08 ppm averaged for 1 hour).

Levels of fluorides as measured in vegetation and by fluoridation candles were higher south of Courtright during 1981 compared to levels of recent years. However, phytotoxicology surveys did not reveal vegetation damage off company property during 1981.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors to measure levels of a number of pollutants that may directly or indirectly adversely affect health, vegetation or the enjoyment of property. Data on levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore the effectiveness of pollution abatement, as well as to provide information on the effect of specific sources of pollutants and to formulate strategies to control pollution.

In April 1981 a regulation was introduced for the Sarnia area that requires industries that are major sources of sulphur dioxide to reduce emissions on the basis of ambient levels of sulphur dioxide and forecasted meteorological conditions. This system is described in the section on sulphur oxides.

Ambient air monitoring in the Sarnia area is also conducted by Ontario Hydro, the Lambton Industrial Society and private industry. In addition, the effects of air pollutants on vegetation are determined through phytotoxicology surveys conducted by the Ministry of the Environment.

Emissions from industrial or other sources of pollutants located in Ontario are regulated by this Ministry through a Certificate of Approval. There is an integrated co-operative air pollution control program in the Michigan-Ontario international area between Lake Huron and Lake Erie. Ambient air quality data and reports on emissions and compliance with abatement schedules are exchanged and are reported to the International Joint Commission.

DESCRIPTION OF MONITORING NETWORK

Continuous and intermittent monitors for determining levels of pollutants in ambient air are maintained by the Ministry at sites dispersed throughout the Sarnia area. However, monitoring is more intensive in the area of downtown Sarnia because it has a higher potential for elevated levels of pollutants than most other areas in the city. This higher potential is a result of the downtown area being affected by emissions from industries and power plants to the south, as well as by dense vehicular traffic and commercial establishments in the downtown area. The industries and power plants to the south of the downtown area tend to be located along the St. Clair River and plumes from different emission sources may create an additive impact when they impinge on the downtown area. Furthermore, the taller buildings situated in the downtown core affect wind currents and tend to bring pollutants from aloft down towards ground level.

During 1981 the Ministry of the Environment participated in a study co-ordinated by the State of Michigan. The study was designed to gather information needed to form a control strategy for ozone for southeast Michigan. As part of this study, a monitoring station was located

south of Wilkesport (station 14904) from June to September 1981.

Part way through 1981 the suspended particulate sampler at station 14057 was relocated to station 14062. The locations of monitoring sites are illustrated in Figure 1. Also included in Figure 1 are the locations of monitoring sites of Ontario Hydro and the Lambton Industrial Society. Specific locations and pollutants monitored are listed in Table A1, Appendix 1.

Criteria for desirable ambient air quality and the supporting rationale for the establishment of these criteria appear in Table A2, Appendix 1.

METEOROLOGICAL DATA

Meteorological data are utilized in predicting the stability of the atmosphere which affects the dispersion of pollutants. These data also assist in identifying sources of elevated levels of pollutants and in validating mathematical models designed to simulate the dispersion of air pollutants.

The main meteorological tower in the area is located at station 14016 immediately south of Courtright. Wind speed and direction are measured at 10 metres, 30 metres and 92 metres above ground level. In addition, ambient temperature is measured at the 10-metre level and the gradients in temperature between the 10-metre level and the 30- and 92-metre levels are determined. These meteorological data are transmitted by a telemetry system to Toronto where meteorologists utilize them to forecast the stability of the atmosphere. This forecasting feature is an intrinsic part of the Air Pollution Index. Wind speed and

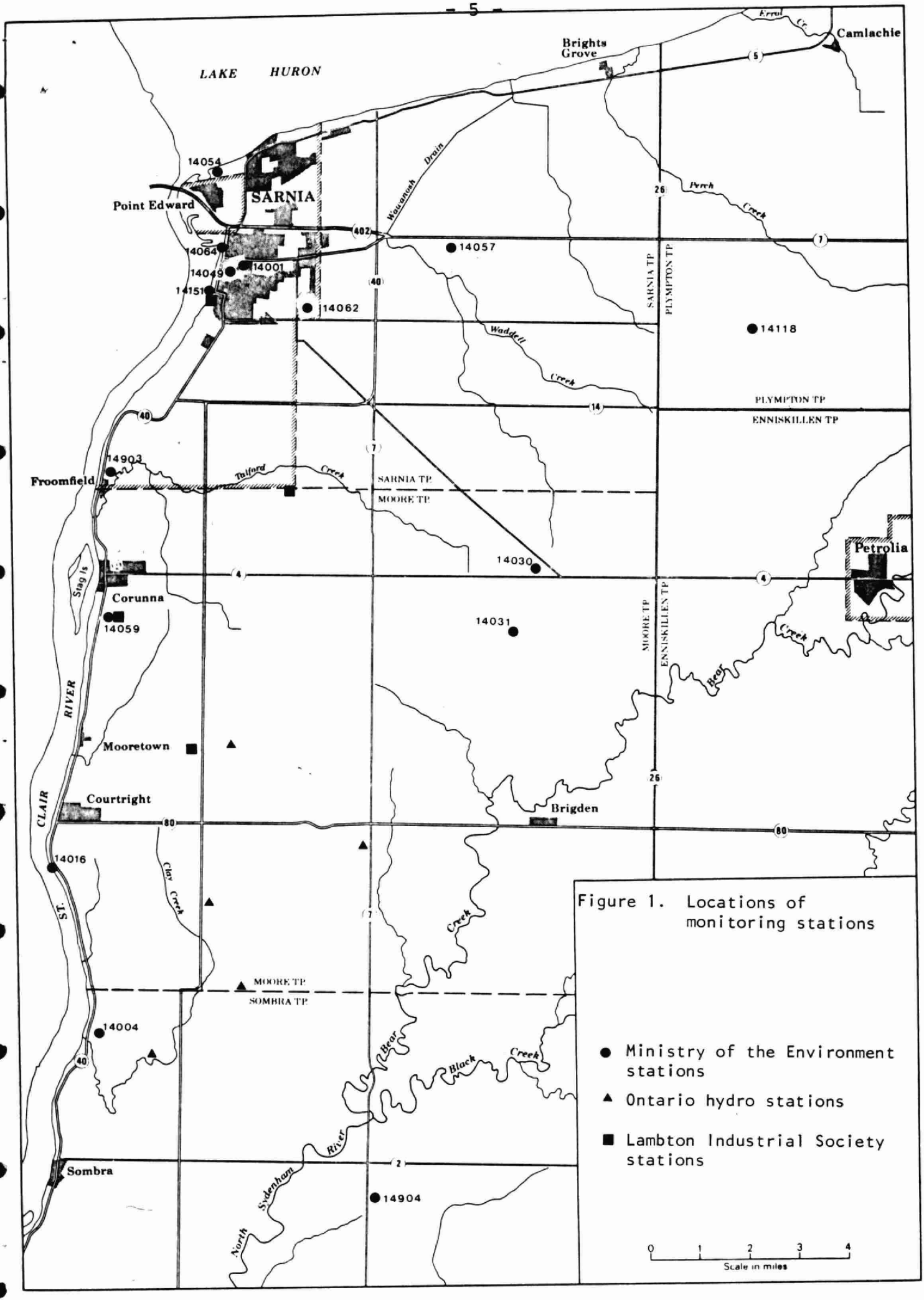


Figure 1. Locations of monitoring stations

- ● Ministry of the Environment stations
- ▲ Ontario hydro stations
- ■ Lambton Industrial Society stations

wind direction are also measured at the 10-metre level at station 14062, located in east Sarnia.

Meteorological data from the 30- and 92-metre levels at station 14016 have been used in computing the average concentration of sulphur dioxide for specific wind directions and to determine the number of hours that the criterion for ozone has been exceeded for different wind directions.

A summary of the frequency of winds for different directions at the 30-metre level of station 14016 appears in Table A3, Appendix 2. The data indicate that the prevailing winds are from the south and southwest.

PARTICULATES

Primary sources of man-caused emissions of particulates to the atmosphere are vehicular traffic, materials handling and combustion processes. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as total suspended particulates, dustfall and soiling index. Total suspended particulates are determined by drawing measured volumes of air through a pre-weighed filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. Dustfall is determined through the exposure of open cylinders (jars) of known diameter for approximately 30 days and subsequently weighing the amount of particulates collected. Soiling index is measured by determining the difference in the amount of light that is transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light

transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Soiling index can be correlated to levels of suspended particulates and can be determined without the time-consuming laboratory analysis required for determining concentrations of total suspended particulates. For these reasons, soiling index is used as a substitute for suspended particulate values when data are required quickly such as in the Air Pollution Index.

TOTAL SUSPENDED PARTICULATES

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m^3. The criterion for 24 hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1981 total suspended particulates were sampled at 10 sites in the Sarnia area. At 7 of the sites sampling was conducted on an every-sixth-day schedule for the year. At station 14057 sampling was conducted on the every-sixth-day schedule until May when the site was terminated. In August, total suspended particulate sampling was initiated on the every-sixth-day schedule at station 14062. At station 14016, suspended particulate monitoring was conducted for the year; however, the every-sixth-day schedule was maintained until October and then daily sampling was conducted. In the future, the daily sampling at station

14016 will be used to evaluate the representativeness of the every-sixth-day schedule.

Levels of total suspended particulates were lower in 1981 than in previous years. This was true for most of southwestern Ontario and eastern Michigan. In the Sarnia area the annual criterion was exceeded only at one site - station 14064 located in Centennial Park adjacent to the downtown-commercial area of Sarnia. The 24-hour criterion was exceeded infrequently at 7 of the 10 stations with the total number of excursions for the year being 16 and the total number of valid samples collected being 577. Of the 16 excursions, above the 24-hour criterion, 7 occurred on one day, May 22, a day when elevated levels of particulate were measured across southwestern Ontario. A summary of 1981 data for total suspended particulates appears in Table 1. Figure 2 shows the annual geometric means and the frequencies of excursions above the 24-hour criterion for 1981 at the approximate locations of the monitoring stations.

Table 1. Summary of 1981 data for total suspended particulates.

Station No.	No. of samples collected	Annual geometric mean (ug/m^3)	No. of values greater than 24-hour criterion	Percentage of values greater than 24-hour criterion
14001	58	44	1	2
14016	128	32	0	0
14030	57	39	2	4
14031	58	43	1	2
14054	57	51	3	5
14057[1]	24	(40)	1	2
14059	56	47	1	2
14062[2]	24	(46)	0	0
14064	58	62	4	7
14151	57	55	4	7

Note: Bracketed annual geometric means are not representative of sampling for complete year.

1. Terminated May, 1981.

2. Start Aug, 1981.

The improvement in 1981 levels of total suspended particulates compared to previous years is illustrated by Figure 3. This figure indicates that for 5 monitoring sites[1] in operation since 1972 the average of the annual geometric means decreased steadily from 1972 to 1975, remained relatively constant from 1975 to 1980 and dropped appreciably in 1981. Similarily the average frequency of excursions above the 24-hour criterion was lowest in 1981.

In general, levels of total suspended particulates in the Sarnia area compare favourably with levels reported for other areas of Ontario.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 4 stations in the Sarnia area were analyzed for cadmium, chromium, copper, iron, lead, manganese, nickel, vanadium, nitrates and sulphates. For 3 additional stations samples were analyzed for nitrates and sulphates and for 2 of the 3 additional sites lead was analyzed. A summary of the data for 1976 through 1981 is contained in Table A4, Appendix 3.

(1) The 5 stations are 14001, 14016, 14054, 14151 and 14064. Station 14064 replaced station 14049 in 1978 but comparison studies revealed that the levels of suspended particulates were similar.

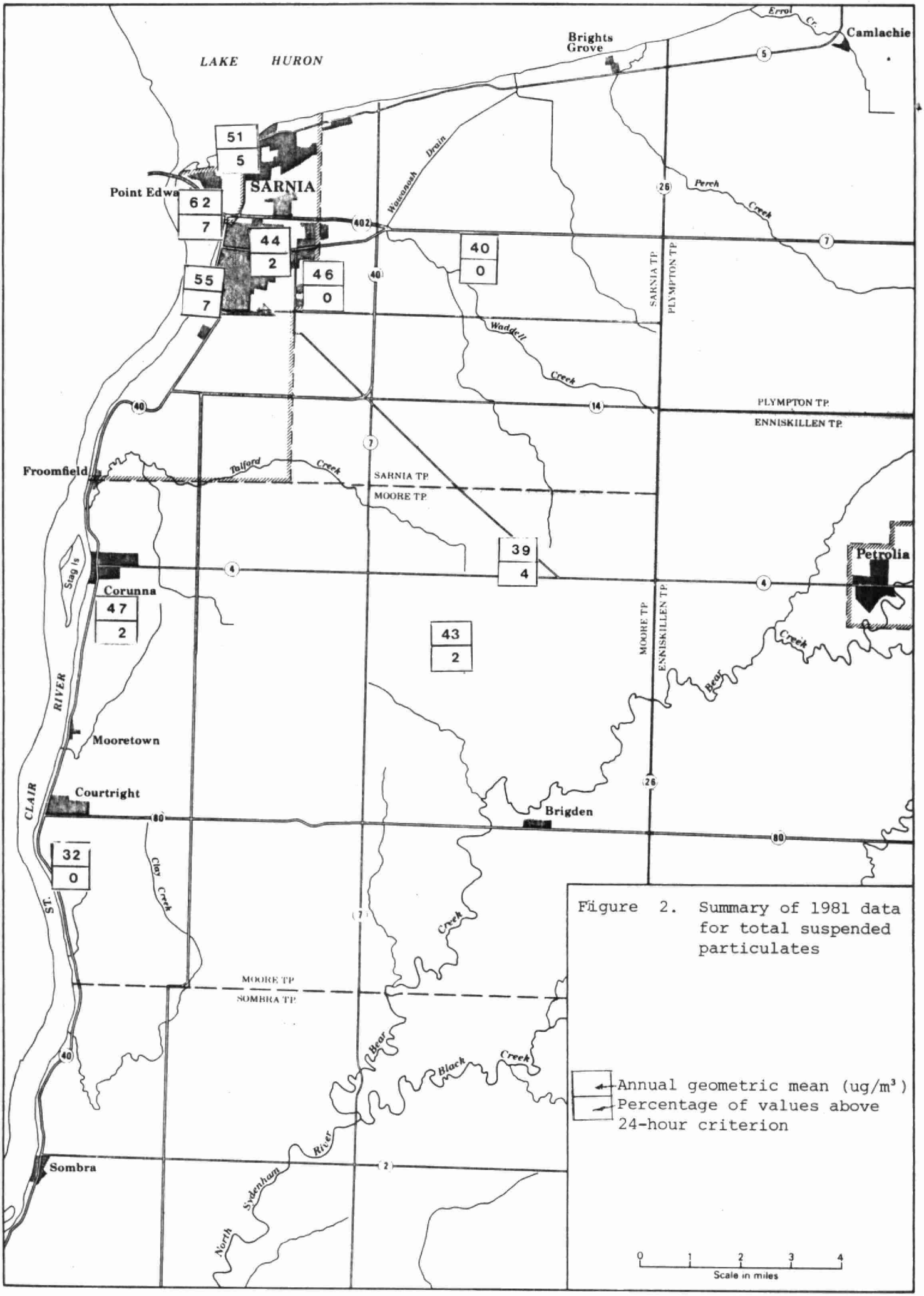
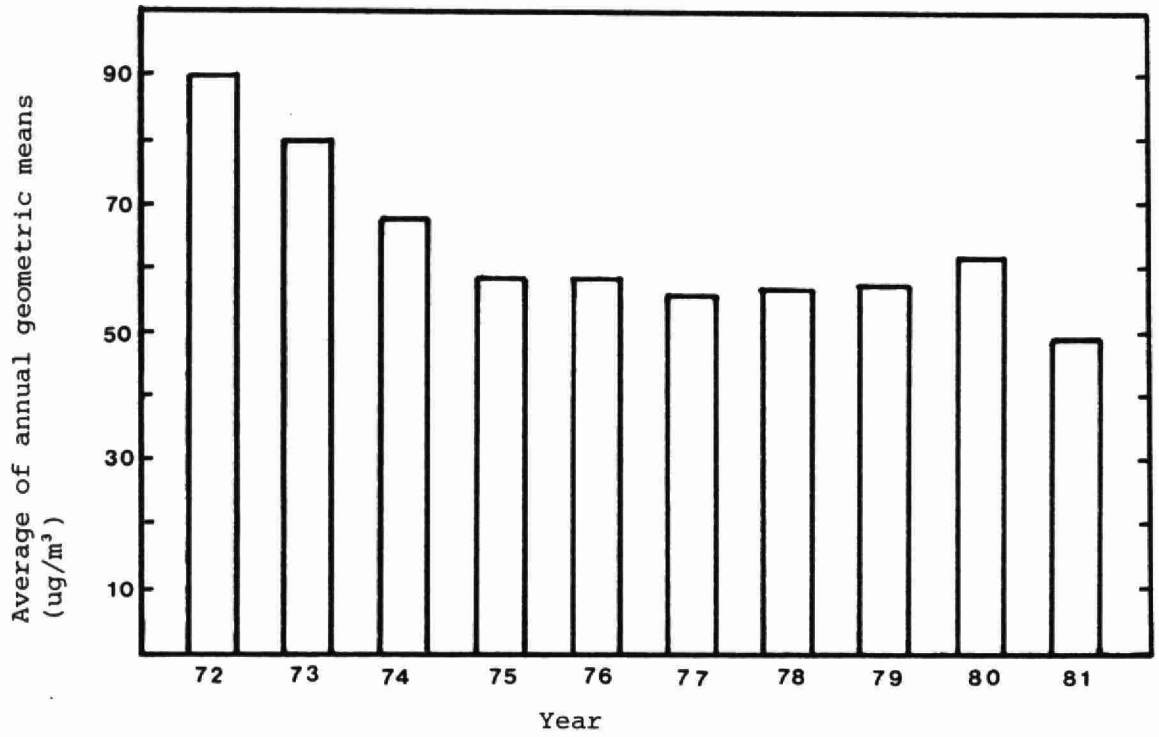
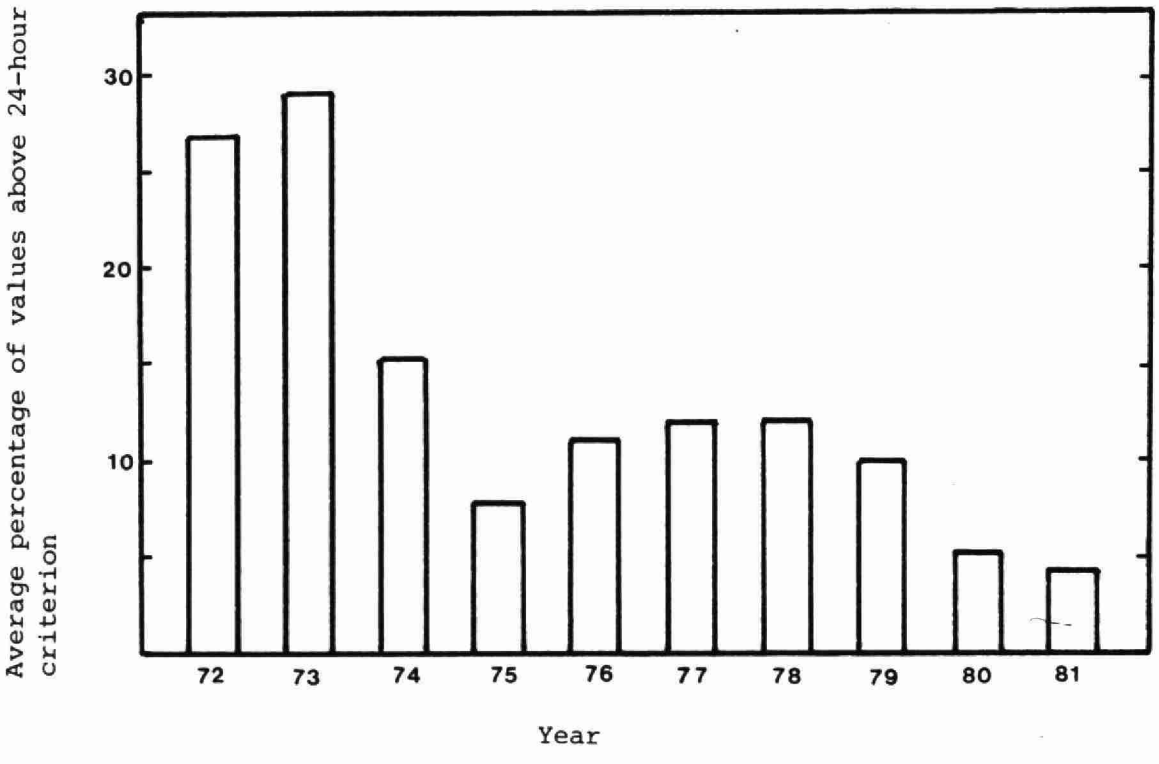


Figure 2. Summary of 1981 data for total suspended particulates

Figure 3. Trend in levels of total suspended particulates based on data averaged for five monitoring stations





Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium. There have been no values above the criteria and in general the concentrations of the various metals have been low. Average levels of nitrates and sulphates were marginally lower in 1981 compared to 1979 and 1980 levels.

DUSTFALL

The Ministry of the Environment's criteria for desirable ambient air quality with respect to dustfall are 7.0 grams of particulates per square metre per 30 days ($g/m^2/30$ days) in any single month and an annual average of 4.6 $g/m^2/30$ days. These criteria are based on historical data and criteria established by other enforcement agencies.

During 1981 dustfall was sampled at station 14151, located in the downtown core of Sarnia. There were no measurements above the 30-day or annual criteria. In general, dustfall levels measured in the downtown core of Sarnia compare favourably with levels measured in other communities. Table 2, contains the data for station 14151 from 1972 through 1981.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. In the Sarnia area large quantities of these fuels are consumed by power-generating plants in Michigan and Ontario and by petroleum and petrochemical industries located south of downtown Sarnia.

Table 2. Values for dustfall (g/m²/30 days) in downtown Sarnia

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Arithmetic Mean
Station 14051 (14151)													
1972				7.4			2.1	6.7	4.9	3.9		3.2	4.7
1973	3.5	2.5	6.3	5.6	6.3	6.3	1.8	2.5	2.8	4.9	5.6	2.8	4.2
1974	3.2	4.9	7.0	7.0	5.6	7.0	4.9	2.8	4.2	4.6	3.2	4.2	4.9
1975	4.6	2.1	4.2	2.1	5.6	5.2	4.2	9.1	3.5	5.6	4.2	2.1	4.4
1976	3.2	4.9	6.7	5.3	4.9	4.6	3.5	3.2	2.8	3.2	2.8	2.8	4.0
1977	0.9	3.9	5.6	5.5	4.9	5.2	4.6	4.0	5.1	3.1	4.4	4.4	4.3
1978	1.5	0.9	19.7	12.7	6.3	5.4	4.8	4.3	7.2	4.7	4.6	3.7	6.3
1979			4.6	6.2		4.3	4.9	2.0	3.0	3.1	3.5		4.0
1980	2.2	1.9	3.8	4.0	3.5	5.3	2.0	3.5	5.7	3.8	2.1	2.2	3.3
1981	1.0	2.9	2.1	5.5	4.5	4.5	3.7		5.7	4.4	2.6	1.6	3.5

Underlined values exceed either the criterion of 7.0 g/m²/30 days or the annual criterion of an average of 4.6 g/m²/30 days.

Station 14051 was replaced with station 14151 in February 1979.

The Ministry of the Environment monitors sulphur oxides in the Sarnia area using continuous gaseous sulphur dioxide analyzers and by analyzing suspended particulate matter for sulphate.

SULPHUR DIOXIDE

Throughout 1981 the Ministry measured gaseous sulphur dioxide at 4 separate sites in the Sarnia area. At an additional site slightly south of Wilkesport sulphur dioxide was monitored for 96 days. There were 12 other sites where monitors providing continuous measurements of sulphur dioxide were operated by Ontario Hydro, the Lambton Industrial Society or private industry. Data from these 12 sites are not included in this report.

Data are reported as 1-hour average concentrations, 24-hour average concentrations (midnight to midnight) and annual average concentrations. Criteria for desirable ambient air quality are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for a 1-hour period, 0.10 ppm averaged for 24 hours and 0.02 ppm as an annual average. The criteria for the 1-hour and annual averages are based on the protection of vegetation while the 24-hour criterion is based on the protection of human health.

There has been concern about the frequency of excursions above the 24-hour criterion for desirable ambient air quality in the downtown area of Sarnia. In April 1981 a new regulation called LIMA[1] became effective. This regulation requires major industrial emitters of sulphur dioxide to provide additional controls either continuously or when required by this Ministry. The Ministry may require

(1) Lambton Industrial Meteorological Alert

industry to provide more controls when meteorological conditions conducive to adverse air quality are likely to persist and sulphur dioxide levels are elevated at specified monitoring sites. This control strategy has been extremely successful. Since the regulation went into effect the 24-hour criterion has not been exceeded at the Ministry monitoring stations. On December 21, 1981 the 24-hour criterion was exceeded at a monitoring station which is located in downtown Sarnia and operated by the Ontario Research Foundation for the Lambton Industrial Society. However, this excursion was only marginally above the criterion and would probably not have occurred if a communication problem within this Ministry had not resulted in a 7-hour delay in requesting industrial sources to cut back on emissions.

Figure 4 shows the frequency of excursions above the 24-hour criterion at stations 14049 and 14064, located in downtown Sarnia, at station 14062 in east Sarnia and at stations 14004 and 14016 located south of Courtright. It is very evident that excursions have occurred most frequently in downtown Sarnia and that 1981 was the first year since monitoring began that an excursion was not detected.

Table 3, contains a summary of the 1981 sulphur dioxide data. The annual criterion was not exceeded during 1981. The 1-hour criterion was exceeded on 3 occasions at station 14062 and on no occasions at the other monitoring stations. The 3 excursions above the 1-hour criterion represent the least number of excursions measured in a year by the Ministry's monitoring network in the Sarnia area.

Figure 4. Trend in frequency of excursions above 24-hour criterion for sulphur dioxide, 1972 to 1981.

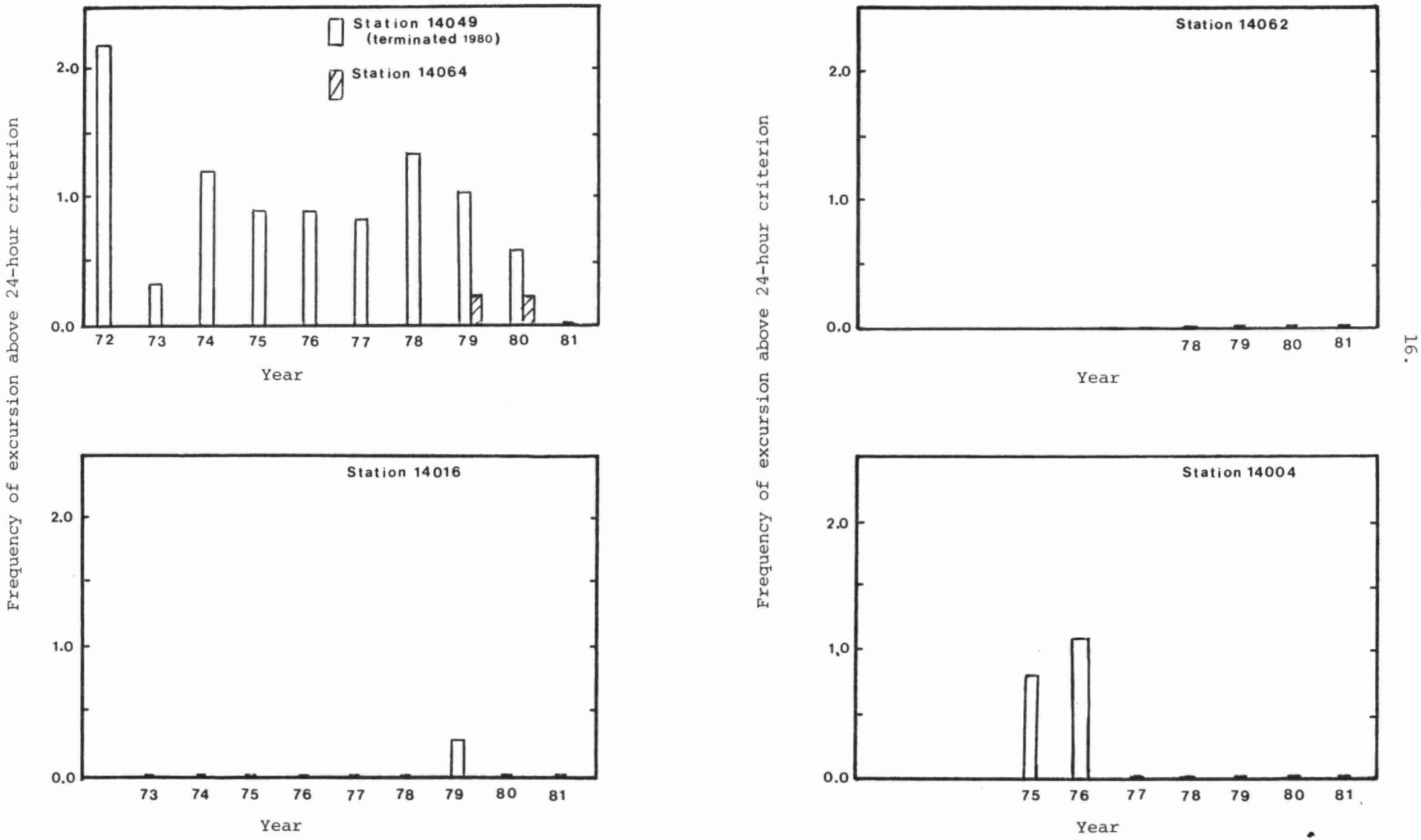


Table 3. Summary of 1981 data for sulphur dioxide

Station No.	Annual average (ppm)	Percentage of values above criterion 1-hour	24-hour	Maximum 1-hour value (ppm)	Maximum 24-hour (daily value (ppm)
14004	0.00	0	0	0.22	0.03
14016	0.01	0	0	0.16	0.04
14062	0.01	0.04	0	0.43	0.05
14064	0.01	0	0	0.24	0.10
14904	0.00(1)	0	0	0.14	0.04

Note (1): Average for 96 days, not representative of annual average.

Pollution roses for sulphur dioxide measurements are shown in Figure 5. The roses were created using data for wind direction and speed from the 30-metre level of station 14016 and concentrations for sulphur dioxide determined at the various stations. The length of the line corresponding to a specific wind direction indicates the average sulphur dioxide concentrations when the winds are from that direction. The roses for stations 14064 and 14062, located in downtown Sarnia and east Sarnia respectively, reflect appreciably higher levels of sulphur dioxide when winds are blowing from the direction of industries located in south Sarnia and immediately south of Sarnia. The roses for the two stations south of Courtright do not reveal an appreciable impact from the nearby power generating stations of Ontario Hydro and Detroit Edison.

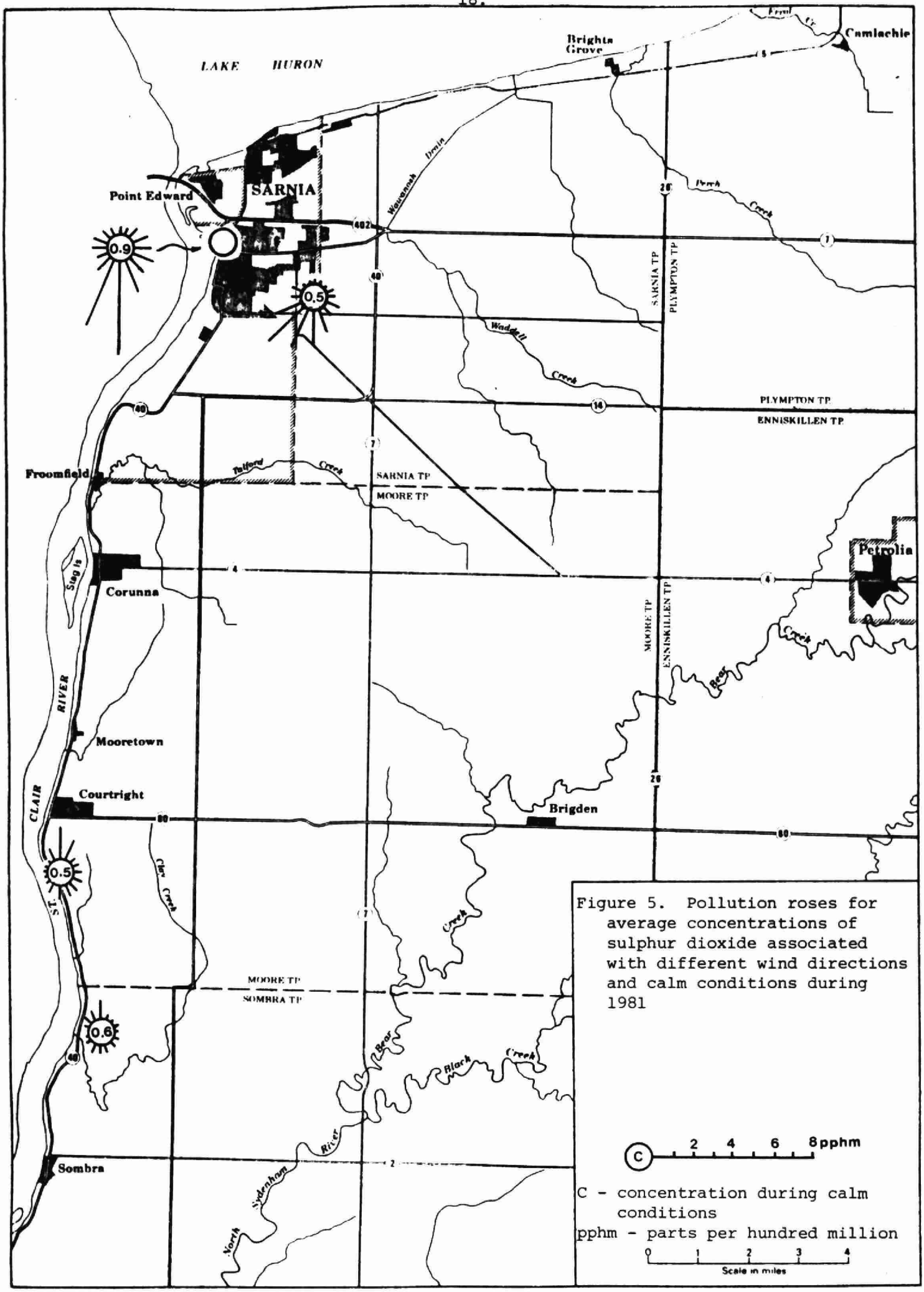


Figure 5. Pollution roses for average concentrations of sulphur dioxide associated with different wind directions and calm conditions during 1981

C 2 4 6 8 pphm

C - concentration during calm conditions

pphm - parts per hundred million

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and current readings of sulphur dioxide and suspended particulates are utilized to predict the potential for persistence of pollution conditions that are reported as the API.

Data for suspended particulates are provided by the measurements of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted in the following equation:

$$API = 3.02\ (9.75\ COH + 125.95\ SO_2)^{0.76}$$

where: COH is the 24-hour running average for soiling index expressed in units of coefficient of haze. SO_2 is the 24-hour running average for sulphur dioxide expressed in parts per million.

The sulphur dioxide and soiling index data utilized to determine the API for Sarnia are obtained from monitors operated at station 14064 in the downtown core.

API values below 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, those responsible for major emissions are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other contributors of pollution not essential to public health and safety may be ordered to cease operation.

The LIMA regulation to control sulphur dioxide would result in sulphur dioxide emissions being curtailed well before the API reached 50. A very remote possible exception would be if the soiling index were extremely high and levels of sulphur dioxide were low. Since the API was introduced in Sarnia in December 1977 it has not reached 50. For 7 periods it reached 32 and during 6 of these periods sulphur dioxide levels would have been above the LIMA action level, had LIMA existed. Although sulphur dioxide levels were quite low for the seventh period, the API reached a maximum of 33 and therefore was not near the alert level of 50 when industries may be required to curtail operations.

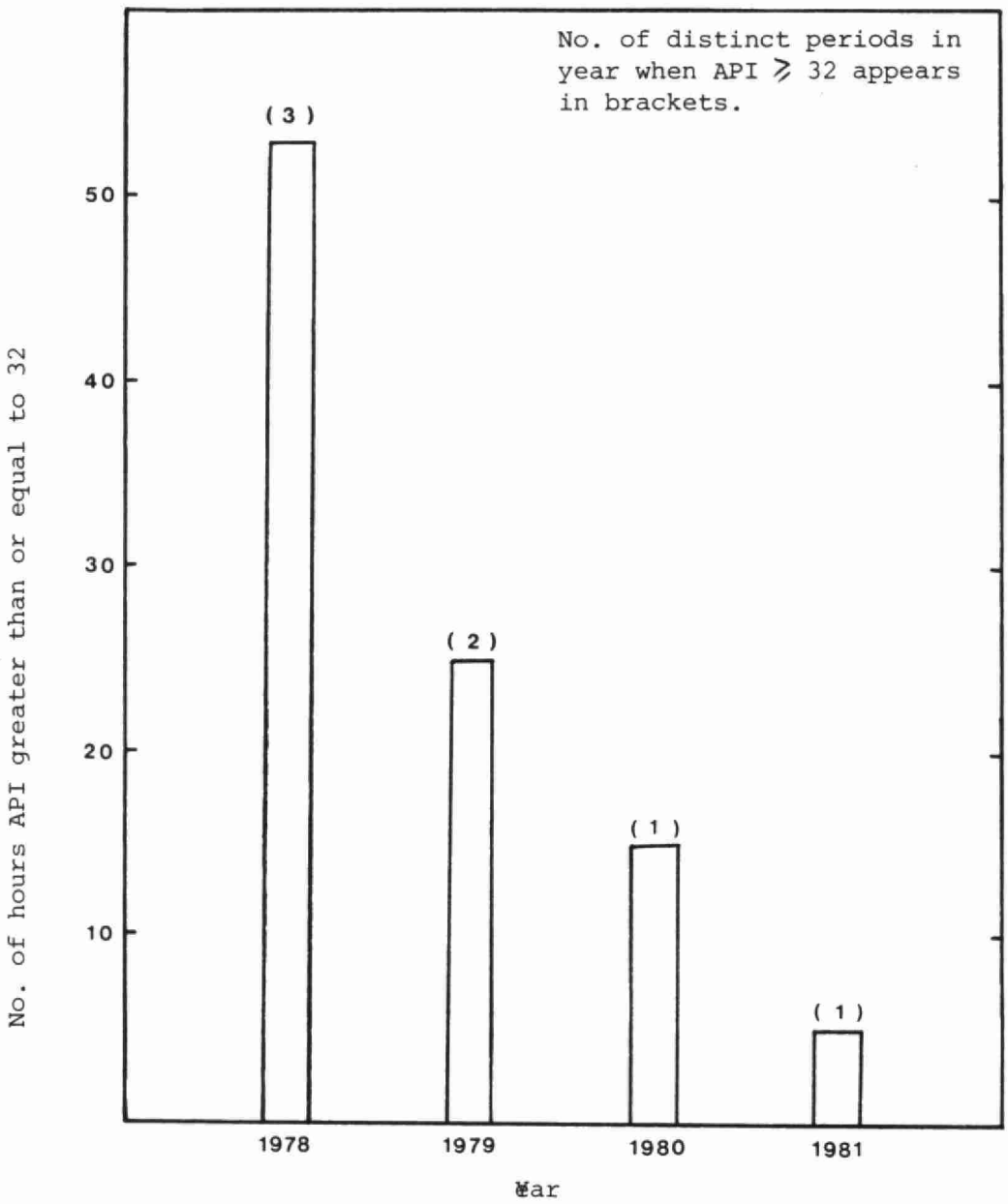
During 1981 the API exceeded 32 for 5 consecutive hours on February 16 with the maximum API being 34. A favourable comparison can be made between 1981 levels and levels of previous years as can be seen in Figure 6. It should be noted that there have been no API levels above 32 since the LIMA regulation came into effect in April, 1981.

HYDROGEN SULPHIDE AND MERCAPTANS

Mercaptans are a group of organic compounds that contain sulphur and hydrogen and exhibit characteristics similar to hydrogen sulphide. Hydrogen sulphide is commonly referred to as "rotten egg gas" and many mercaptans are also malodorous at extremely low concentrations.

Both hydrogen sulphide and mercaptans originate in nature from anaerobic decomposition of organic matter containing sulphur. In the Sarnia area, the release of hydrogen sulphide and mercaptans into the atmosphere may result from the processing of petroleum feedstocks containing sulphur.

Figure 6. Trend in Air Pollution Index levels



The criterion established to represent desirable ambient air quality with respect to hydrogen sulphide is 0.02 ppm as an average for 1 hour. This criterion is based on the offensive odours exhibited by this gas. Similarily, the criterion for mercaptans is based on odour and was established as 0.01 ppm averaged for 1 hour and expressed as methyl mercaptan.

Unfortunately, the monitoring instrument in Sarnia does not segregate hydrogen sulphide from mercaptans but determines their combined concentrations and reports these concentrations as hydrogen sulphide. However, the monitoring instrument over-responds to some mercaptans such that the concentration would be reported as more than an equivalent amount of hydrogen sulphide. In consideration of these shortcomings the combined concentrations of hydrogen sulphide and mercaptans are compared to the less restrictive criterion for hydrogen sulphide.

During 1981 the hourly criterion of 0.02 ppm was exceeded for 1 hour at station 14062 located in east Sarnia. The excursion occurred during a period of calm wind conditions. A pollution rose, Figure 7, constructed with the use of wind speed and direction data from the 30-metre level indicates higher levels of hydrogen sulphide and mercaptans during calm conditions and when winds are blowing southwest from the industrialized area.

The summary in Table A5, Appendix 4 shows that the data have been very comparable in recent years with very infrequent excursions of the 1-hour criterion.

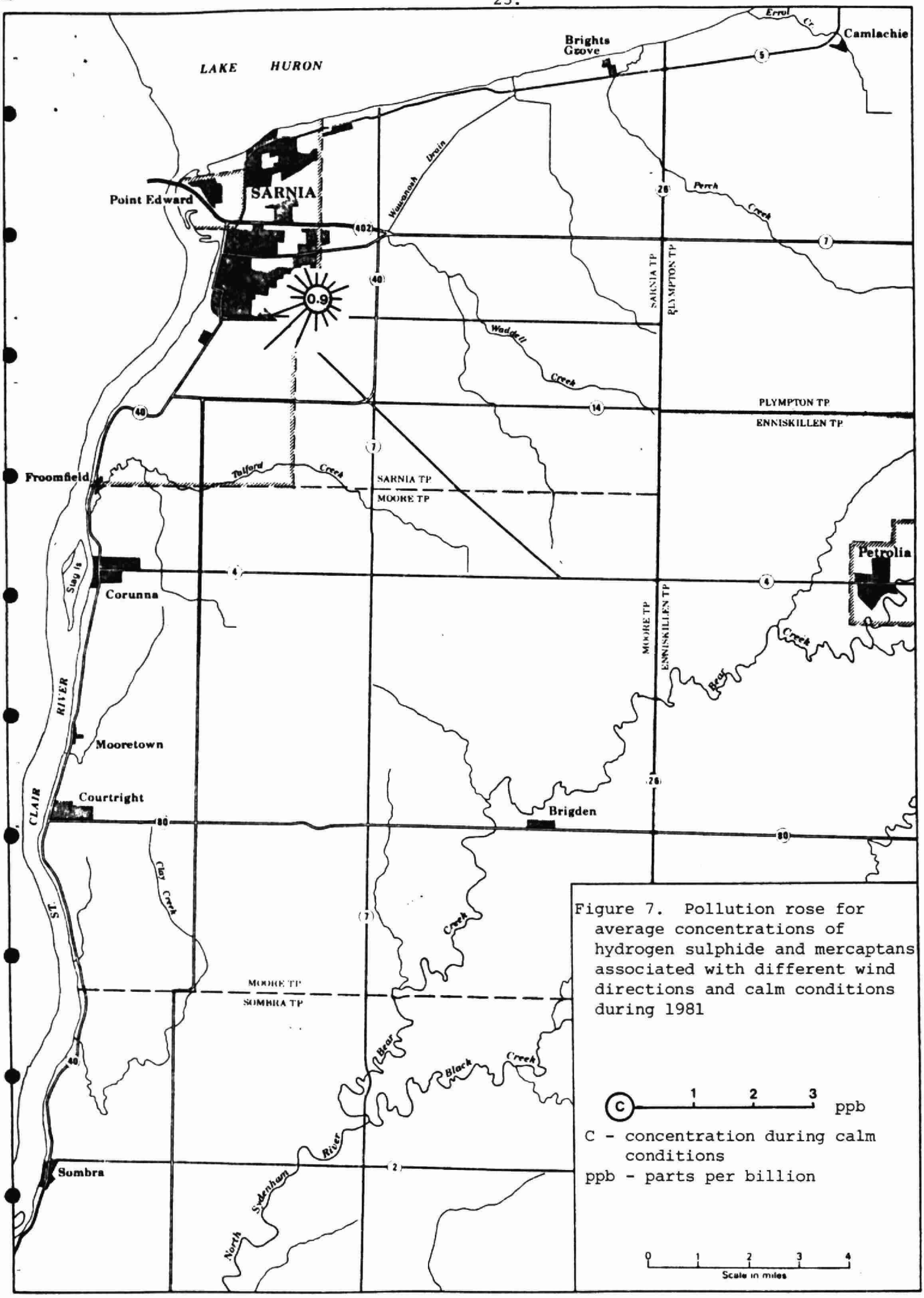


Figure 7. Pollution rose for average concentrations of hydrogen sulphide and mercaptans associated with different wind directions and calm conditions during 1981

C 1 2 3 ppb

C - concentration during calm conditions

ppb - parts per billion

CARBON MONOXIDE

Combustion processes represent man's major emissions of carbon monoxide. Emissions from motor vehicles are most significant because they occur near ground level and are concentrated in urban areas where the public may be exposed for lengthy periods. Industries and power-generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in the ambient air.

The criteria for carbon monoxide, which are based on the protection of human health, are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8-hour period.

During 1981 carbon monoxide was monitored at station 14064, located in the downtown core at Centennial Park. The criteria for desirable ambient air quality were not exceeded. Prior to July, 1978 carbon monoxide was measured in downtown Sarnia at station 14049. A summary of data for carbon monoxide obtained since 1974 is presented in Table A5, Appendix 4, and illustrates long-term conformity below established criteria.

OXIDES OF NITROGEN

Gaseous oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are the gaseous compounds of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria, which are based on offensive odours and the protection of human health, are

0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours. The Ministry's monitoring program has not detected an excursion of these criteria in the Sarnia area since monitoring for oxides of nitrogen was introduced in 1972. Monitoring began at station 14049 in downtown Sarnia and in July 1978 was relocated to station 14064 in Centennial Park. Monitoring has also been conducted for a number of months in Corunna, south Sarnia, and a rural location in south Lambton County with no values being detected above the criteria. Since 1974 monitoring has been conducted with instruments utilizing chemiluminescence technology.

A summary of data for oxides of nitrogen appears in Table A5, Appendix 4. Levels are in ranges typical of communities the size of Sarnia.

Oxides of nitrogen in combination with reactive hydrocarbons and certain meteorological conditions play an important role in the formation of unsatisfactory levels of photochemical oxidants. Also, oxides of nitrogen react to form acids which are part of acidic precipitation. Therefore, consideration is being given to further controls on emissions of oxides of nitrogen.

HYDROCARBONS

Emissions from motor vehicles are a primary man-made source of hydrocarbons in the ambient air. Other significant man-made sources are incomplete combustion of fuels by industries and power plants, and evaporation losses during the storage and transportation of hydrocarbons. Natural phenomena also produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Values for total hydrocarbons were measured at station 14064 in the downtown core of Sarnia, at station 14903 in the extreme south of Sarnia and station 14904 in southern Lambton County near Wilkesport. At station 14064 the average level of total hydrocarbons was slightly greater than in previous years but lower than levels measured prior to July 1978 when total hydrocarbon monitoring in the downtown core was conducted at station 14049.

At station 14903 in south Sarnia monitoring was conducted for 4 months in 1981 as a follow-up of a 1980 investigation into periodic elevated levels of non-methane hydrocarbons. The monitoring instrument reported values for total hydrocarbons, methane and non-methane hydrocarbons. When levels of non-methane hydrocarbons were elevated, a sample of ambient air was collected in a multi-layered aluminized bag and sent to the Ministry's Toronto laboratories for analysis. The analytical results did not reveal any levels of specific hydrocarbons that were unacceptable.

As part of a co-operative study with the State of Michigan total hydrocarbons, methane and non-methane hydrocarbons were measured at station 14904 in southern Lambton County during the summer of 1981. At this rural location, levels of hydrocarbons were slightly lower than measured at station 14064 during the same period.

A summary of data for hydrocarbons appears in Table A5, Appendix 4.

OXIDANTS

Oxidants in the ambient air are primarily a result of a series of photochemical reactions and inter-rections involving oxides of nitrogen and non-methane hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intensive sunshine, resulting in higher levels of oxidants in the spring and summer months.

Throughout 1981 the Ministry monitored oxidants in the form of ozone at station 14064 in the downtown core of Sarnia, and at station 14118, situated in a rural setting approximately 10 kilometres east of Sarnia. Ozone was also measured from June 5 to September 14, 1981 at station 14904, located in a rural location in southern Lambton County. Ozone normally accounts for 80 to 95 percent of the oxidants present in ambient air. Consequently, with technology for monitoring ozone being more accurate and efficient than for total oxidants, most regulatory agencies monitor for ozone.

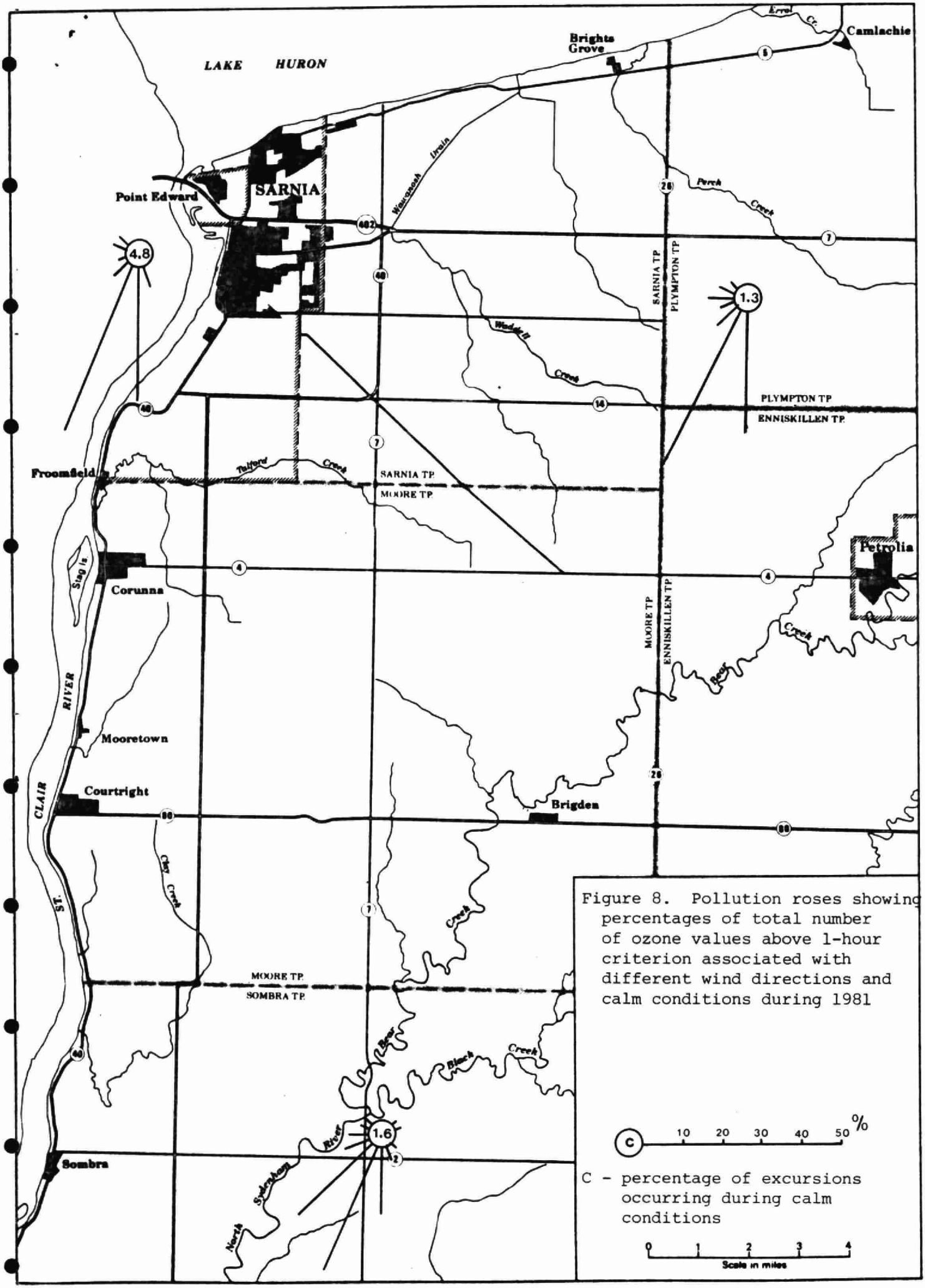
Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) may account for a very significant portion of local levels of ozone. Long-range transport from distances greater than 200 kilometres has been reported in the literature. Therefore, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario. As a result of the United States-Canada Memorandum of Intent on Transboundary Air Pollution, signed August 5, 1980, working groups represented by experts from both countries are addressing the significance of long-range transport of ozone and its precursor chemicals.

During the summer of 1981 the Ministry of the Environment assisted the State of Michigan in a study to determine the impact of emissions from the Detroit area on downwind ozone levels. This study revealed that areas downwind of Detroit, such as Lambton County, are significantly affected by emissions from Detroit as well as by the longer-range transport of ozone and its precursor chemicals. The State of Michigan is developing a control strategy to reduce the impact of emissions from the Detroit area. The U.S. Environmental Protection Agency requires the states where the U.S. primary standard for ozone (0.12 ppm averaged for 1 hour) is exceeded to submit a control strategy plan showing attainment of the standard by December 31, 1987.

In addition to ozone formed by photochemical reactions in the troposphere, ground level concentrations of ozone are occasionally increased by ozone from the stratosphere being transported downward. Ozone is naturally produced in minor amounts by lightning.

Ontario's criterion for desirable ambient air quality established for ozone is 80 parts per billion (ppb) averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some oxidant-related effects that are detrimental to health are eye irritation and a decrease in performance during athletic endeavors.

During 1981 the criterion was exceeded 67 times at station 14064, 85 times at station 14118 and 69 times at station 14904. Pollution roses for 1981 are presented in Figure 8 to show the frequency of the total number of excursions above the criterion associated with different wind directions. The greatest frequency of excursions are associated with southerly and south-southwesterly winds. These winds are apt to be associated with the backs of high


LAKE HURON
Brights Grove
Errol Cr.
Camlachie
SARNIA
Point Edward
Wawanosh Drain
Perch Creek
4.8
1.3
SARNIA TP
PLYMPTON TP
Wedekind Creek
PLYMPTON TP
ENNISKILLEN TP
Froomfield
Telford Creek
SARNIA TP
MOORE TP
Petrolia
Corunna
Stag Is.
MOORE TP
ENNISKILLEN TP
Bear Creek
CLAIR RIVER ST.
Mooretown
Courtright
Brigden
Clay Creek
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
1.6
Sombra
North Sydenham River
Figure 8. Pollution roses showing percentages of total number of ozone values above 1-hour criterion associated with different wind directions and calm conditions during 1981
C 10 20 30 40 50 %
C - percentage of excursions occurring during calm conditions
0 1 2 3 4
Scale in miles

pressure systems or the area south of low pressure fronts which have weather favourable for photochemical reactions (clear sunny skies and warmer temperatures) and which promote long-range transport of oxidants and their precursor chemicals from the United States.

A summary of data for ozone appears in Table A6 of Appendix 4. Fluctuations from year to year may be attributable to variances in meteorological conditions and/or emissions.

FLUORIDES

In the Sarnia area fluoride is emitted into the atmosphere from fossil-fueled power plants where it exists as an impurity in coal, from a fertilizer plant where it occurs as a constituent of phosphate rock, and from petroleum refineries where it is used as a catalyst in alkylation.

Fluoridation rate is a measurement designed to indicate relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and subsequently analyzed for fluoride content. This technique is inexpensive compared to other methods for measuring airborne fluorides. Some fluorides in particulate form are collected on the filters.

Criteria for desirable ambient air quality established for fluoridation rate are based on protection of vegetation. A criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) exists for the growing season of April 15 to October 15. A less stringent criterion of 80 ug F/100 cm^2/30 days exists for the period of October 16 to April 14.

Since the months of April and October are common to both criteria and fluoridation rate is determined on a monthly basis, excursions above the criteria during these months are determined by comparing fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days).

The Ministry monitors fluoridation rate at station 14004, located south of Courtright in the vicinity of the fertilizer complex of Canadian Industries Limited and power plants of Ontario Hydro and Detroit Edison. Canadian Industries Limited has maintained a detailed network of fluoridation candles for many years and also operates a continuous gaseous fluoride analyzer.

During 1981 the criterion for the growing season was exceeded for the 5 consecutive months of May through September and the fluoridation rate for October exceeded the average of the two criteria. The less-stringent criterion for the non-growing season was not exceeded. Frequent excursions of the growing season criterion have been occurring at station 14004 since monitoring began in 1976. However, the 1981 values from May through September were higher than corresponding values for previous years. The 1981 phytotoxicology survey conducted by the Ministry did not reveal vegetation damage attributable to fluoride off company property. The 1981 levels of fluorides in vegetation were also the highest in recent years. Table 4 presents the data for fluoridation rate from 1976 to 1981.

Although the Ministry is concerned about the increased levels of fluoridation rate and fluorides in vegetation during 1981, it recognizes that the fluoridation rate measurement technique is not very precise. Also, there are limitations in the phytotoxicology studies that restrict their use in short-term trend evaluations. Consequently the Ministry is investigating fluoride monitoring techniques and will carefully review 1982 data for any continuation of an upward trend.

Table 4. Fluoridation rates measured at station 14004 from 1976 to 1981 (ug F/100 cm^2/30 days)

Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Average
1976						46	38	74	48	39	21	40	44
1977	42	23	53	32	78	31		79	112	29	104	50	58
1978	83	51	53	57	100	65	94	74	74	57	53	59	68
1979	32	63	25	56	54	64	68	129	89	49	32	26	57
1980	16	23	51	62	61	49	83	84		36	28	31	48
1981	48	48	30	49	69	78	116	122	95	71	55	24	67

NOTE: Underlined values exceeded criteria for desirable ambient air.

APPENDIX I

MONITORING NETWORK

Table A1. Locations of monitoring stations and parameters being monitored.

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14001	Sarnia General Hospital	Suspended particulates	16 m.	Historical station which has been in operation since 1962. Does not reflect ground level concentrations but does indicate more direct effects of particulates from high stacks and long-range transport.
14004	5½ miles south of Courtright	Continuous SO_2 fluoridation rate	4 m.	Monitors SO_2 from power generating stations and fluorides from fertilizer industry.
14016	1¼ miles south of Courtright	Suspended particulates continuous SO_2, WS, WD, Temp., WS, WD, Temp., WS, WD, Temp., telemetering equipment	1 m. 10 m. 30 m. 92 m.	Monitors suspended particulates and sulphur dioxide in relation to power generating plants. Provides meteorological data required for stability forecasts and air quality interpretations.
14030	R. R. #1 Corunna	Suspended particulates	3 m.	Monitors particulates in the vicinity of of Tricil Limited.
14031	R. R. #1 Mooretown	Suspended particulates	3 m.	Monitors particulates in the vicinity of Tricil Limited.
14049	Victoria Street	Continuous SO_2, suspended particulates, dustfall, fluoridation rate	4 m.	Monitors air pollutants in a heavily populated area where the pollutants from traffic, commercial establishments and the heavily industrialized complex south of the monitoring station should be high relative to residential areas.

Table A1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14054	Sarnia Yacht Club	Suspended particulates	5 m.	Monitors suspended particulates in the north Sarnia-Point Edward area.
14057	Briarwood Recreation Centre	Suspended particulates	10 m.	Monitors suspended particulates in Sarnia Township, northeast of the main industrial area.
14059	Riverbend, Corunna	Suspended particulates	4 m.	Monitors suspended particulates in the residential area of Corunna which is surrounded by industry and generating stations.
14062	Eastland Plaza, 242A Indian Rd. S.,	Continuous SO_2, H_2S & mercaptans WS, WD	6 m. 10 m.	Monitors SO_2, H_2S and mercaptans in residential-commercial area of east Sarnia which is adjacent to refinery operations. Provides meteorological data useful in identifying sources of pollutants.
14064	Centennial Park Front Street, Sarnia	Continuous SO_2, CO, NO, NO_2, NO_x, O_3, total hydrocarbons, 1-hr COH, suspended particulates, telemetering equipment	3 m.	Monitors main air pollutants in an area adjacent to downtown Sarnia and in line with many point sources of pollution located to the south of the downtown area. Provides Air Pollution Index for Sarnia.
14118	Petrolia Public Utilities Commission Pumping Station, 4 miles west of Wyoming.	O_3	5 m.	Monitors ozone levels in a rural location

Table A1. continued

Station No.	Location	Parameters measured	Height of measurements	Purpose of stations and comments
14151	Front and David Streets, downtown Sarnia	Suspended particulates dustfall	3 m.	Monitors pollutants in commercial area which is also affected by heavily industrialized area to south. Since this is the location of a monitoring station operated by the Lambton Industrial Society, cross checking of monitoring techniques is possible.
14903	Virgil St., Sarnia	Continuous SO_2, NO, NO_2, NOx, O_3, Methane, total & non-methane hydrocarbons, suspended particulates, wind-speed and direction.	3 m. 10 m.	Main air pollutants in small residential area of southern Sarnia using instrumented van for eight months.
14904	East Sombra Public School	Continuous SO_2, NO, NO_2, NO_x, O_3, methane, total hydrocarbons & non-methane hydrocarbons.	3 m.	Established to monitor ozone and precursor chemicals downwind of prevailing winds from Detroit area during summer of 1981.

Table A2. Desirable ambient air quality criteria established for Ontario

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Dustfall	7.0 g/metre^2 in 30 days	Historical and in keeping with other control agencies
	4.6 g/metre^2 (mean monthly average in 1 year)	
Fluoridation rate	40 ug F/100 cm^2 of limed filter paper in 30 days during April 15 to October 15.	Protection of vegetation
	80 ug F/100 cm^2 of limed filter paper in 30 days during October 16 to April 14.	Protection of vegetation (less restrictive criterion during the non growing season)
Hydrocarbons (total, methane & non-methane)	NONE	Effects of hydrocarbons vary widely depending on their chemical-physical nature. Certain non-methane hydrocarbons may react photochemically to produce oxidants.
Hydrogen sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours.
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours.
Nitric oxide	NONE	Reacts with oxygen to produce NO_2.
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against offensive odours.
	0.10 ppm averaged for 24 hours	Protection of human health and protection against offensive odours.

Table A2. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Oxides of nitrogen	NONE	
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, adverse health effects
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged for 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m³ averaged for 24 hours	Based on health effects in conjunction with elevated levels of SO_2 and impairment of visibility.
	A geometric mean of 60 ug/m³ during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of human health
Lead in suspended particulates	5 ug/m³ averaged for 24 hours	Protection of human health
	A geometric mean of 2 ug/m³ over a 30-day period	Protection of human health
Nickel in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of vegetation
Vanadium in suspended particulates	2.0 ug/m³ averaged for 24 hours	Protection of human health

APPENDIX 2

METEOROLOGICAL DATA

Table A3. Percent frequencies of wind directions at the 30-metre level of station 14016.

Year	N	NE	E	SE	S	SW	W	NW
1981	13.8	9.9	4.5	7.8	18.6	15.8	11.9	17.7
1980	12.6	8.6	5.6	7.5	20.1	15.1	14.4	16.1
1979	10.7	8.7	6.5	8.9	24.7	14.7	11.9	14.0
1978	13.6	12.7	6.3	6.0	19.0	17.2	11.9	13.3
1977	11.3	9.8	5.3	7.2	18.5	21.2	14.1	12.6
1976	12.2	9.2	3.5	4.7	18.1	20.5	15.1	16.7
1975	9.4	11.6	6.7	7.6	19.3	20.5	12.9	12.1
1974	12.2	10.6	5.2	5.7	20.6	21.6	12.1	12.1
1973	11.6	11.0	8.1	7.2	15.8	20.6	12.9	12.8
1972	15.8	12.0	6.5	8.3	17.4	16.4	11.7	12.0

APPENDIX 3

PARTICULATES

Table A4. Concentrations (ug/m³) of various constituents of suspended particulates: 1976 to 1981.

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
14001															
1976	10	0.001	0.004	10	0.017	0.066	10	0.31	0.73	10	1.0	2.4	10	0.3	0.6
1977	18	0.000	0.003	18	0.009	0.030	18	0.68	2.48	18	1.2	5.8	18	0.3	1.3
1978	24	0.001	0.005	24	0.010	0.023	24	0.22	0.54	24	1.1	4.0	24	0.2	0.7
1979	32	0.001	0.003	32	0.003	0.013	32	0.23	0.62	32	0.8	3.0	32	0.2	0.4
1980	24	0.001	0.004	24	0.001	0.007	24	0.19	0.56	24	0.9	2.3	24	0.3	0.5
1981	54	0.001	0.003	54	0.003	0.014	54	0.12	0.29	54	0.7	2.6	54	0.2	0.4
14016															
1976	18	0.000	0.003	18	0.003	0.011	18	0.41	1.17	18	0.6	1.6	18	0.2	0.4
1977	21	0.000	0.002	21	0.008	0.025	21	0.31	0.58	21	0.6	1.8	21	0.2	0.6
1978	26	0.001	0.003	26	0.007	0.019	26	0.50	1.38	26	0.9	3.2	26	0.1	0.4
1979	35	0.001	0.004	35	0.002	0.010	35	0.39	1.01	35	0.8	2.9	35	0.2	0.6
1980	25	0.001	0.004	25	0.002	0.009	25	0.44	0.96	25	0.6	1.8	25	0.1	0.4
1981	124	0.001	0.004	124	0.003	0.014	124	0.19	1.59	124	0.6	2.6	124	0.1	0.3
14030															
1978	11	0.002	0.004	11	0.007	0.019	11	0.37	0.98	11	1.2	2.2	11	0.3	0.9
1979	50	0.001	0.004	50	0.007	0.022	50	0.32	1.36	55	0.6	2.2	54	0.1	0.4
1980	52	0.001	0.004	52	0.003	0.023	52	0.47	2.34	52	0.5	1.5	52	0.1	0.3
1981	58	0.001	0.009	58	0.005	0.053	58	0.17	0.56	58	0.7	4.5	58	0.1	1.4
14031															
1978	12	0.002	0.003	12	0.004	0.008	12	0.44	1.00	12	0.7	1.3	12	0.1	0.3
1979	54	0.001	0.005	54	0.010	0.189	54	0.25	0.97	58	0.5	2.7	54	0.1	0.4
1980	54	0.001	0.004	54	0.005	0.030	54	0.13	0.26	54	0.5	2.2	54	0.1	0.3
1981	58	0.001	0.003	58	0.005	0.035	58	0.15	0.95	58	0.6	2.6	58	0.1	0.2
14051 (14151)															
1976	17	0.001	0.003	18	0.032	0.157	17	0.08	0.15	17	1.0	3.4	17	0.3	0.8
1977	20	0.000	0.003	20	0.007	0.021	20	0.10	0.28	20	0.6	1.3	20	0.2	0.5
1978	21	0.001	0.005	21	0.006	0.016	21	0.09	0.40	21	1.0	3.1	21	0.3	0.9
1979	30	0.001	0.007	30	0.004	0.016	30	0.05	0.27	30	1.5	4.9	30	0.3	0.7
1980	21	0.002	0.004	21	0.007	0.012	21	0.07	0.18	21	1.4	2.6	21	0.3	0.6

Table A4. continued

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
14001															
1976	2	0.30	0.37	10	0.029	0.107	58	3.8	15.8	58	8.6	44.6	10	0.02	0.11
1977	18	0.04	0.23	18	0.014	0.064	47	4.7	24.5	48	12.9	43.9	18	0.01	0.07
1978	24	0.08	0.58	24	0.010	0.033	52	4.6	21.3	51	11.1	39.7	24	0.00	0.02
1979	32	0.06	0.38	32	0.010	0.076	54	4.8	16.0	54	11.0	35.7	32	0.01	0.07
1980	24	0.03	0.13	24	0.010	0.033	55	5.5	18.4	55	13.4	28.6	24	0.01	0.04
1981	54	0.03	0.10	54	0.008	0.064	58	4.8	19.1	58	11.1	25.6	54	0.01	0.14
14016															
1976	8	0.01	0.04	18	0.013	0.031	96	4.0	20.0	105	8.7	33.4	18	0.00	0.02
1977	21	0.03	0.09	21	0.022	0.165	54	3.7	27.8	54	10.0	24.6	21	0.01	0.08
1978	26	0.02	0.06	26	0.016	0.194	53	4.6	24.6	53	11.2	35.3	26	0.00	0.10
1979	35	0.02	0.07	35	0.008	0.042	56	5.4	14.8	56	12.4	41.0	35	0.00	0.01
1980	25	0.02	0.10	25	0.010	0.064	56	4.8	11.4	56	11.5	25.1	25	0.01	0.10
1981	124	0.02	0.12	124	0.005	0.045	128	4.2	13.5	126	8.7	37.0	124	0.01	0.08
14030															
1978				11	0.009	0.013									
1979	45	0.01	0.05	50	0.006	0.032							45	0.00	0.02
1980	50	0.01	0.08	52	0.004	0.026							50	0.00	0.01
1981	51	0.02	0.10	56	0.004	0.034	51	4.4	13.7	51	9.5	27.6	51	0.01	0.03
14031															
1978				12	0.016	0.057									
1979	46	0.02	0.07	54	0.009	0.171							46	0.00	0.01
1980	52	0.02	0.11	54	0.005	0.021							47	0.01	0.02
1981	52	0.02	0.14	58	0.004	0.020	50	3.7	10.1	52	9.6	28.2	52	0.01	0.02
14051 (14151)															
1976	17	0.03	0.07	17	0.023	0.084	59	3.7	11.7	58	9.3	45.1	17	0.03	0.12
1977	20	0.03	0.06	20	0.009	0.022	56	3.9	22.4	56	10.9	32.1	20	0.00	0.02
1978	21	0.06	0.18	21	0.012	0.047	59	5.4	19.2	59	12.8	47.1	21	0.01	0.12
1979	30	0.06	0.33	30	0.018	0.077	44	6.1	25.4	44	13.5	42.2	30	0.02	0.10
1980	21	0.05	0.15	21	0.015	0.076	59	4.9	16.2	59	12.3	26.5	21	0.02	0.07
1981							57	4.9	13.7	57	11.4	27.8			

Table A4. continued

Station and Year	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Lead # of samples	Lead Avg.	Lead Max
14054									
1976	54	3.7	13.2	61	8.9	34.8	3	0.2	0.3
1977	49	3.8	20.2	49	10.1	25.7	15	0.2	0.5
1978	49	4.8	20.4	49	11.5	37.0	57	0.2	1.3
1979	55	5.1	14.3	55	12.5	39.2	55	0.2	1.1
1980	57	5.2	14.8	57	12.4	27.6	53	0.2	1.0
1981	57	4.3	14.1	57	10.2	30.0	57	0.1	0.3
14064									
1981	58	4.7	16.2	58	11.2	29.5	58	0.1	0.6

APPENDIX 4

HYDROGEN SULPHIDE AND MERCAPTANS, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for hydrogen sulphide and mercaptans, carbon monoxide, oxides of nitrogen and hydrocarbons.

Pollutant and Criteria	Station number	Year							
		1981	1980	1979	1978	1977	1976	1975	1974
Hydrogen sulphide and mercaptans									
Annual average (ppm)	14062	0.000	0.000	0.001	0.001				
	14049				0.001	0.001	0.001	0.001	0.007
Percentage of values above 1-hr criterion[a]	14062	0.01	0.00	0.01	0.00				
	14049				0.15	0.01	0.04	0.38	9.78
Carbon Monoxide									
Annual average (ppm)	14064	0	0	0	0				
	14049				1	2	1	1	1
Percentage of values above: 1-hr criterion	14064	0	0	0	0				
	14049				0	0	0	0	0
8-hr criterion	14064		0	0	0				
	14049				0	0	0	0	0

Table A5. continued

Pollutant and Criteria	Station number	Year							
		1981	1980	1979	1978	1977	1976	1975	1974
Nitric oxide									
Annual average (ppm)	14064	0.01	0.01	0.02	0.02				
	14049				0.02	0.02	0.02		
	14904[b]	0.00							
Nitrogen dioxide									
Annual average (ppm)	14064	0.02	0.02	0.02	0.02				
	14049				0.03	0.03	0.03	0.02	
	14904[b]	0.01							
Percentage of values above: 1-hr criterion	14064	0	0	0	0				
	14049			0	0	0	0		
	14904	0	0						
24-hr criterion	14064	0	0	0	0				
	14049			0	0	0	0		
	14904	0							

Table A5. continued

Pollutant and Criteria	Station number	Year							
		1981	1980	1979	1978	1977	1976	1975	1974
Total oxides of nitrogen									
Annual average (ppm)	14064	0.03	0.03	0.04	0.03				
	14049				0.05	0.05	0.05	0.05	
	14904[b]	0.01							
Total hydrocarbons									
Annual average (ppm)	14064	2.1	1.9	2.0	1.7				
	14049				2.6	2.4	2.3	2.6	2.8
	14903[b]	2.2	2.3						
	14904[b]	2.0							
Methane									
Annual average (ppm)	14903[b]	1.7	1.8						
	14904[b]	1.7							
Non-methane hydrocarbons									
Annual average (ppm)	14903[b]	0.4	0.6						
	14904[b]	0.3							

Note: (a) Criterion for hydrogen sulphide
(b) Annual averages based on less than full year of data

Table A6. Summary of data for ozone

Station and Parameter	Year							
	1981	1980	1979	1978	1977	1976	1975	1974
Station 14049								
Annual average (ppm)				0.023	0.020	0.019	0.024	0.018
Number of values above 1-hr criterion				51	87	56	132	80
Percentage of values above 1-hr criterion				1.1	1.0	0.7	1.9	1.1
Station 14064								
Annual average (ppm)	0.021	0.022	0.023	0.018				
Number of values above 1-hr criterion	67	68	130	56				
Percentage of values above 1-hr criterion	0.8	0.8	1.6	1.4				
Station 14118								
Annual average (ppm)	0.023	0.022	0.027	0.029	0.027			
Number of values above 1-hr criterion	85	39	137	249	182			
Percentage of values above 1-hr criterion	1.0	0.5	1.7	3.5	2.6			

Table A6. continued

Station and Parameter	Year 1981	1980	1979	1978	1977	1976	1975	1974
Station 14904[a]								
Annual average (ppm)	0.031							
Number of values above 1-hr criterion	69							
Percentage of values above 1-hr criterion	2.9							

(a) Data not representative of full year - instrument operated from June 5 to September 14, 1981.

DATE	ISSUED TO